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TYPHOID FEVER IN CLEVELAND, OHIO, FOR THE YEARS 1918, 1919, AND 1920.[1]

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CONTENTS.

Introduction.

Beginning with 1911 and up to 1917, seven annual reports on the prevalence of typhoid fever in Cleveland, Ohio, by members of the third year class in hygiene at Western Reserve Medical School, were published in the *Cleveland Medical Journal;* and the present article is intended to bring the records up to date. During the war period, the general dislocation of men and consequent interference with satisfactory routine resulted in more or less unsatisfactory records. The attempt has been to follow back as many cases as possible for their epidemiological data, but with only partial success. The records for 1920, as received from the division of health, are much more satisfactory than those of the previous years, and suffer mainly in that there has been incomplete reporting of cases by doctors and hospitals. In this year, however, it has been possible to get hold of many of these unreported cases and analyze them, so that the records for 1920 are the best we have had.

[1] From the Department of Hygiene and Bacteriology, Western Reserve University School of Medicine, and the Bureau of Laboratories, Cleveland Division of Health.

It will therefore be evident that the figures in this article will not agree with official figures from the division of health, in that many unreported cases have been added and cases of obvious out-of-town origin have been omitted in the final tabulation. The inadequacy of the records for 1918–19 makes it probable that there was a more extensive out of town series than noted; but, of course, where information was not definite, the responsibility was placed on the city.

An interesting feature of any discussion of typhoid or other epidemiology in a city like Cleveland, with large independent suburbs divided from the city proper by an imaginary line, is that, on the one hand, there are cases which may be infected in the city but live in the suburbs and are consequently reported to the State and not to the municipality, and that, on the other hand, there are cases which live within the city limits, but pass so much of their time at work in the suburbs that it is hard to place responsibility. At the present time (1921) the writer is attempting to overcome some of this difficulty through cooperation with the State health department, both through its central epidemiological bureau and the health commissioner of Cuyahoga County, in which Cleveland is situated. In this way it is hoped that next year a report may be made out for Greater Cleveland to include the area supplied by the city water and drained by the city sewage system.

Sources of information.—The records of the doctors of the health division, of the water department, of the various hospitals, and of the Weather Bureau have been freely used, and recognition of their value is here expressed. Where the records were insufficient, personal investigation has supplemented them to some degree, especially in connection with out of town cases, and much assistance has been received from the doctors who cared for the cases. The writer desires to express his thanks for preliminary work in the collection of data for 1918 and 1919 by Dr. Emerson Megrail, instructor in the department of hygiene.

Division of the year.—The division of the year into fly-breeding period and nonfly-breeding period, which was adopted in the earlier reports, has been retained, the fly-breeding period including the months of July to November. While at this latitude, and in a city, the fly as an etiological factor in typhoid fever is of minimal importance, the fact that much of the outlying district of the city is, in part, unsewered and, consequently, has many privies, makes such a division valuable.

Incidence and Mortality.

Analysis by months and years.—Tables I and II show the incidence of typhoid fever from 1910 to 1920, inclusive. The important years

in the series are 1911, as in September of that year the dosage of the city water with hypochlorite was begun, and 1918, as in April of that year the greater part of the city began to receive filtered water. In every case the totals show, in addition to the official figures, such unreported cases as could be uncovered; but it is clear from the apparent mortality, as determined from the relation of deaths to cases, that many more have never reached us. In each year since 1913 a subtraction of the out-of-town cases has been made, and the calculation has been altered accordingly.

TABLE I.—*Annual incidence of typhoid fever in Cleveland, by months, 1910-1920, inclusive.*

Month.	Year.										
	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920
January	24	32	24	13	20	7	10	23	7	2	3
February	16	23	7	20	29	9	16	12	5	4	3
March	38	49	20	20	13	25	11	15	6	3	5
April	102	37	22	49	7	10	15	18	7	1	5
May	25	27	23	39	10	21	17	11	3	2	9
June	18	40	17	20	16	19	11	18	5	11	5
July	22	24	31	33	34	15	20	15	28	10	17
August	95	80	41	59	36	52	38	36	33	9	19
September	123	167	58	83	43	39	51	32	21	10	14
October	104	62	62	39	25	27	27	31	17	16	18
November	48	38	27	32	20	20	17	9	3	11	8
December	41	18	19	28	17	6	12	10	8	5	10
Total	656	[1] 622	351	435	270	250	245	230	143	84	162
Imported	......	......	......	......	33	71	64	83	22	24	44
Cleveland cases	......	......	......	......	237	179	181	147	121	60	118
Rate (crude) per 100,000	111	106	51	68	41	36	34	31	19	10.1	20.0
Corrected rate	......	......	......	......	36	26	25	20	16	7.6	14.5

[1] Including unreported cases.

TABLE II.—*Annual mortality from typhoid fever in Cleveland, 1910-1920, inclusive.*

	Year.										
	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920
Total	105	85	38	84	54	54	36	53	37	20	25
Out of town cases	......	7	2	5	6	9	4	13	2	3	6
Cleveland cases	......	78	36	79	48	45	32	40	35	17	19
Rate (crude) per 100,000	18.6	14.0	6.2	13.2	8.2	7.9	5.1	7.2	5.0	2.7	3.1
Corrected rate	......	13.3	5.8	12.4	7.3	7.1	4.5	5.4	4.7	2.2	2.3

Analysis of cases according to age and sex distribution shows nothing new and is of value only as additional statistical information. For this reason, three years (1918, 1919, and 1920) have been combined in the data presented in Table III.

TABLE III.—*Incidence of typhoid fever in Cleveland, by age groups and sex, for the years 1918, 1919, and 1920 combined.*

Age (years).	Sex.		Total.	Age (years).	Sex.		Total.
	Male.	Female.			Male.	Female.	
1		1	1	30-34	31	9	40
2	2	4	6	35-39	25	13	38
3		2	2	40-44	18	4	22
4	2	6	8	45-49	7	3	10
5-9	28	22	50	50-54	1	4	5
10-14	28	23	51	55-59	2	2	4
15-19	38	15	53	60 and over	1		1
20-24	36	18	54				
25-29	24	10	34	Total	243	136	[1] 379

[1] Age not obtainable in 20 cases.

Out of Town Cases.

As usual, there are some cases which had their origin outside of Cleveland and can not be attributed to local conditions. There are a great variety of ways in which these cases may be dealt with. The present series is arranged in the following manner:

A. Persons arriving in the city after onset, or arriving less than two weeks before onset, are considered as out-of-town cases.

B. Persons whose occupation keeps them out of the city for the greater part of the time, such as traveling salesmen, firemen and conductors on trains, sailors on the lakes, etc., and who give a history of eating and drinking at many places, without special precautions, are also so considered.

C. Cases originating where local epidemics, in connection with picnics or other assemblages, are clearly established, with the necessary etiological relations, also admit of exclusion.

D. In cases where the responsibility appears to be more or less divided, or where the period elapsing between arrival and onset of illness is at the border line of the incubation period, it is safer to include them among the city list, even at the risk of unfairness.

In this connection an interesting technical point has arisen. A luncheon was given at a country club outside the city limits, and was attended by some 200 persons. The catering was done by a Cleveland firm, most of the personnel of the firm being residents of Cleveland. About two weeks afterwards there was an outbreak of typhoid among the guests, about 40 of whom were infected. Investigation in the city laboratory, under direction of the writer, showed the presence of a carrier among the caterer's personnel. Although the majority of those taken sick were residents of the suburbs and did not come into the Cleveland figures, yet there were several Cleveland people, and it is of interest to decide their classification. Had the carrier not been determined, they would have been out of town

cases, as being infected outside of the city area; but inasmuch as the carrier was a Cleveland resident, only accidentally outside of the city, it was Cleveland that was clearly responsible, not only for the cases reported to the health division but for the remainder which were reported to the State. For the sake of uniformity the Cleveland cases have been placed in the out of town series, as there were only three of them; but there is no doubt where the responsibility lies. This outbreak is reported elsewhere in greater detail, as it is not included in the Cleveland series.

As a general rule, the majority of out of town cases come in the summer or vacation periods, and the deletion of all these from the graphs lowers the curve for those months nearer to the norm of the other months. It is our hope that when the water element is entirely gone, removal of these cases will leave so nearly a flat curve that carrier cases may be much more readily found.

In 1918, out a total of 143 cases reported, there were 22 out of town, or 15.4 per cent. Of these, 19 occurred in July and August, lowering the curves for those months very materially.

In 1919, out of a total of 84 cases, there were 24 out of town, or 28.6 per cent, a rather unusual figure, but evidently due to the small number of town cases with about the same annual figure of out of town cases.

In 1920, out of 162 cases, there were 44 out of town, or 27 per cent, indicating that if the records had been as good in the previous years the number assigned to Cleveland might have been somewhat smaller.

Etiology.

The usual etiological factors include food and beverages, together with water supplies, flies, and contacts, and in the present instance most of these may be more or less briefly dismissed.

FLIES.

The distribution of the cases throughout the city during the months in which fly breeding is going on actively does not show any especial relation to the districts in which the sewer system is incomplete and in which flies might be supposed to gain access to feces. For the most part in the built-up districts, where the deep water-worn gullies make a sewerage system impracticable until more filling has been carried out, the privies are in the form of vaults and are not readily accessible. In the outlying districts, where the city has more the character of the country, there are too many of the old type of privies, and a few cases of typhoid fever which may possibly have a fly etiology; but in all of these cases other factors are also present, and the total number is too small for conclusions. Through all the series for the last 10 years this has been true. In fact, as the sanitary con-

ditions improve and more and more districts are connected with the sewerage system, the number of cases even possibly related to flies approaches zero.

CONTACTS.

Although, of course, many of the persons in whom no definite etiology was established, obtained the infection through contact, there are few cases in which there is any evidence. The following brief notes summarize the available information:

1918: Two boys were taken sick on July 18 and 26, respectively, and cared for by their mother. Her case was reported to the bureau on September 7.

A boy was taken sick July 27, and cared for at home. On August 20, two cases in children in the same family, both under 9 years of age, were reported.

A fatal case, with onset on September 14, was cared for in the same lodging house as was a subsequent case in a boy of 9, with onset on October 8.

1919: A boy taken sick August 26 was the older brother of a subsequent case in the same house, with onset on September 9.

1920: There is one suggestive series in which it was difficult to make a final determination. A girl of 13 was at a fresh-air camp near Cleveland for two weeks and was taken sick a few days after her return home. Investigation showed that part of the water supply at the camp was polluted, but that at the time of the girl's visit there was no case of typhoid there. There had been a case in one of the workers, who had developed typhoid so soon after arrival that it is probable that she obtained the infection in Cleveland before departure, but she had been taken away to a hospital some two weeks before the arrival of the girl. The incubation time, however, would appear to indicate that the girl received her infection at the camp. The water supply was cared for, and there were no other cases; but of course it is not known if there would have been any under other circumstances. Two weeks after the girl returned home, but only 10 days from the apparent date of onset, the sister, living elsewhere but eating with the family, was taken sick; and three days later, both the father and mother became ill. All cases were taken to the Lakeside Hospital, and there is no doubt of the diagnosis of typhoid. At first sight it looks like a series of contact cases infected by the girl who returned from the camp in the incubation period; her activities in the household made it entirely possible for her to have infected the food, but the brevity of the interval between the date of onset in her case and in the cases of the rest of the family, is an obstacle to this possibility. It is hard to isolate the typhoid bacilli from the feces during the first week after onset, or, approximately, until the earliest time for the appearance of a

Widal; but if she was the infecting cause, the transfer must have taken place not later than the third or fourth day. She was not cared for by the sister who came down first, and it looks as though the infection, if it did take place, probably came through the food, as this was practically the only contact which the sister had.

The main argument in favor of this contact is the practically identical onset of the three other members of the family and the absence of any occasion other than lunch at which they were all present. It is, of course, possible that the working daughter was infected separately and that the time of onset was a coincidence.

MILK.

The entire milk supply of the city is pasteurized, with the exception of the certified milk, and no series of cases occurred in which any reference to any special milk supply could be noted. In this connection it is of interest to note that there have been no epidemics of sore throat referable to milk since the pasteurization ordinances became effective.

FOODS.

One outbreak, occurring in 1920, is definitely attributable to food and is of a good deal of interest, being the subject of a special report published elsewhere. At a country club luncheon attended by a large number of women, one of the caterer's assistants was a carrier, and within two weeks some 40 of the guests and attendants came down with typhoid, two of whom died. The matter was taken up by the health division, although the outbreak occurred outside the city limits, and the carrier was discovered. The majority of the patients were not residents of the city and, accordingly, the cases were not reported to us. This outbreak has already been mentioned under the head of out-of-town cases.

WATER SUPPLIES.

The question of water supplies must be divided into several sections, each of which has its own importance. The supply of the city is of two types: On the one hand, the supply coming from the mechanical filter plant on the West Side, opened in April, 1918, and supplying the greater part of the city; and on the other hand, the supply coming from the old pumping station on the East Side, where there is no filtration, but where liquid chlorine is used, and which supplies the east and north sections of the city, over a fairly sharply limited area. In addition to this there are in the parks certain springs, tested at frequent intervals and closed when unsatisfactory, and in the outlying districts a fair number of wells, most of which are more or less unsafe

and are being closed as fast as sufficient pressure can be brought on the owners. Another water problem relates to the bathing beaches and pools and will be taken up separately.

SPRINGS AND WELLS.

All the known springs in the city limits are numbered and under the supervision of the health division. They are all shallow, and are practically surface water filtered through a sandy soil, as the whole city, save the extreme southern portion and the high ground to the southeast, is on one of the sand benches of the old Lake Erie bottom, cut by numerous erosion gullies, from the sides of which the springs issue. Frequent tests are made and unsatisfactory springs are closed to the public.

In the outskirts of the city there are still a number of wells, and it is certain that many of these are infected. The histories of the cases, however, in practically all instances, gave the city water as their source of supply and denied the use of wells. A survey is to be undertaken this summer with the intention of examining all wells in the city limits and closing the bad ones. It does not seem probable from the histories that more than one or two cases in the whole three years can be attributed to this cause.

BATHING.

There is another factor which is of more importance and relates closely to the character of the water in the lake. This concerns the bathing beaches and bathing pools.

The main bathing areas along the shore of Lake Erie are at Edgewater Park, on the west side, and from Gordon Park eastward on the east side. All these beaches are subject to heavy contamination from untreated sewage, those on the west side from the sewer at the foot of West Fifty-eighth Street, less than a mile away, and draining the greater part of the west side; and those on the east side, from the intercepting-sewer outlet at East One hundred and fortieth, a maximum of 2 miles from any of the beaches and within a mile of many. Laboratory tests of the water at various points show a high degree of pollution, and there is little question that infection can occur while swimming. It is interesting, however, to note that of the many thousands who have used the beaches in the last three years, only 12 give a history of bathing at these points being followed by typhoid infection within a reasonable period. Tabulation of these cases is as follows:

Beach.	Date of bathing.	Date of onset of typhoid fever.
1918—Gordon Park	July 29	Aug. 16.
Edgewater Park	From time to time	Aug. 5.
Euclid Beach	Aug. 1	Aug. 14.
1919—Euclid Beach	June 15	July 7.
Edgewater Park	Sept. 8	Sept. 26.
Sewage-disposal plant	Aug. 31	Sept. 11.
Euclid Beach	Various times	Oct. 4.
1920—Edgewater Park	do	Aug. 4.
Beach Cliff	July 15	Aug. 28.
Overlook Park	Various times	Aug. 22.
Edgewater Park	do	Aug. 30.
Lake, various points	do	July 31.

It is obvious in this series that the interval between exposure to infection and the onset of the disease is within the average of the incubation period of typhoid, and while the fact that other persons in the same vicinity, but with no history of bathing, developed the disease, makes it impossible to make an absolute statement, yet, in the absence of other factors, it seems probable that these cases must be attributed to sewage infection of Lake Erie.

The rest of the bathing cases fall into several groups. There are seven cases in which the patient gave a history of bathing more or less frequently in one of the small watercourses in the city, all of which are open sewers, taking either a direct flow of sewage from the outlets in districts which drain into the lowlands and ultimately into the Cuyahoga River, or the outflow from privies, cesspools, etc., in the unsewered border districts. It is most probable that these cases are direct results of the swims.

Bathing place.	Date of bathing.	Date of onset of typhoid fever.
1919—Riverside Pond off Jennings Avenue	Often	June 24.
Gully at Forty-sixth Street, south of Scovill	do	July 9.
1920—Euclid Creek at Nottingham	do	June 12.
Bedford Glens	May 23	June 14.
Mill Creek at East Seventy-eighth	Often	Aug. 10.
Cuyahoga River		
Creek at Linndale (Brooklyn)	Various times	July 28.
Foot of Clark Avenue		Aug. 3.

Four cases give histories of bathing at out-of-town places as follows:

Bathing place.	Date of bathing.	Date of onset of typhoid fever.
1920—Turkeyfoot Lake near Akron, Ohio	July 5	About Aug. 1.
Linwood Park Ohio	July 15	About Aug. 10.
Cedar Point, Ohio	July 4	About July 28.
Shore Acres (stop 128)	(?)	

Two gave histories of bathing in pools, as follows:

Bathing place.	Date of bathing.	Date of onset of typhoid fever.
1918—Garfield Park	Aug. 10 and 18	Sept. 5.
1920—Jewish Educational Alliance	(?)	Sept. 7.

In these last two series, while in certain cases the dates are conformable to the possibility of infection, it is questionable if much stress can be laid on the relation of the bathing to the disease. The Garfield Park tank is city inspected and tested, and the series of cases of infection from contaminated water in that park occurred at the same time. One patient, a boy of 10, had no recollection of when or where he drank water while in the park.

In summation, then, of 25 cases in which a history of bathing was obtained, 19 had selected highly contaminated places for their baths, and may be considered as probably infected in this manner. Of the remaining six, the dates in four cases of out-of-town visits in districts by no means free from typhoid suggests a very possible etiology dating to the trip, but whether the disease was due to the bathing or to other reasons can only be surmised. In the other two cases, the relation, in the absence of any other cases referable to these sources, may be considered as very doubtful.

USE OF KNOWN POLLUTED SOURCES.

Garfield Park series.—A small but clear-cut group of cases came from the use of a highly polluted water not intended for drinking. Analysis of this series is as follows:

Garfield Park lies on the southern border of the city and has several springs, from which the water is available either by direct flow or by pump. These springs are examined by the city laboratory at frequent intervals in the summer and once a month in the winter. There is also a bathing pool, fed by spring water, and below it, on the slope toward the Cuyahoga River, is a public privy with a sewer draining to the river.

There was a sudden increase of cases among persons living on the South Side, and occurring mostly in young adults. Investigation showed that the outflow from the swimming pool crossed under the road near the car stop for the park and that the contamination from the urinals and public privy also passed this point. A large group of the cases gave a history of drinking this water as they got off the cars, though there was a marked and tested spring less than five minutes' walk away. The park department was advised of the condition and rendered the contaminated water inaccessible. No further cases with this etiology were reported, though special inquiries were made until six weeks after the covering of the stream.

It may be noted that such pollution has always been a problem in connection with the city springs. The soil is sandy and the water is, in the main, a naturally filtered surface water, finding exit on the eroded banks of the Cuyahoga and its tributaries and such creeks as flow directly into Lake Erie. The springs are carefully watched, inasmuch as changing conditions, such as extensive building operations, often cause a pollution of a temporary or permanent character, and, under these conditions, they are closed at once, with the cooperation of the park division. It is, however, the rule to find that the closed springs have been dug out again by those who wish to use the water, regardless of the dangers; and in one case even the addition of a constant flow of road oil, in sufficient amounts to give a very marked odor and taste, seemed only to stimulate the desires of the users. Near the ball grounds in Garfield Park is a surface drainage rivulet which is frequently preferred to the pump at the field. Unless all surface water is covered, an obvious impossibility with a landscaped park, many will use it, often with the results cited in the present instance.

In this small epidemic there were 13 cases with history of onset between July 7 and 31, three dating their onset to August 9, 10, and 11, and one on September 5, which is rather long in incubation relations and which may be due to other causes, since the place was closed off August 5.

WATER DEPARTMENT SUPPLIES.

The accompanying map shows the areas supplied by the two systems. It might be thought easy to determine the relative importance of each from the distribution of the cases; but it must be remembered, however, that the great majority of the residents in one quarter work or shop in another, so that, save in the comparatively few cases of children and housewives who have not been away from their immediate neighborhoods, both sources have been freely used. In fact, a population density map, prepared from the figures of the last census, shows the proportion of cases in the various neighborhoods of equal sanitation to depend mainly on the population per acre. Taken by itself this might suggest that the water bore no relation to the problem, and a careful discussion and analysis of the cases is necessary.

Source.—The ultimate source of the city supply is Lake Erie, through two cribs four and a half miles from the water front opposite the mouth of the Cuyahoga River, which drains a hundred miles of farming watershed dotted with small communities. The water enters through tunnels to the pumping stations, from which it is supplied to the consumer; at the Division Street station after filtration and treatment with liquid chlorine, and at the Kirtland Street station after treatment with liquid chlorine.

Character of untreated water.—With the growth of the city and the increase of the sewage poured into the lake, the quality of the lake water has steadily deteriorated, until at present it shows the presence of *B. coli* in over 85 per cent of 10 c. c. samples, and very frequently in 1 c. c. samples, or even in smaller amounts. It was on account of this progressive deterioration of the supply that the writer induced the city to begin chlorination in 1911 and that he has since urged in season and out of season that the tests showed the chlorination to be inadequate. The figures showing the annual summary of the raw-water tests, Table IV, will sufficiently indicate its quality.

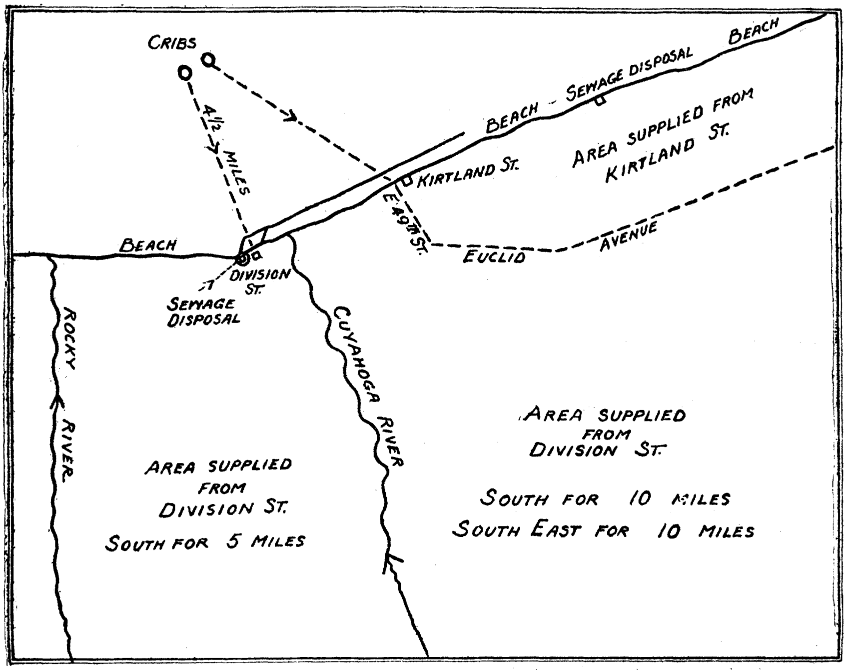

FIG. 1.—Sketch showing the areas supplied by the two water plants. The cribs are four and one-half miles out in Lake Erie.

TABLE IV.—*Annual summary of raw water samples.*

[Figures refer to number of days on which lactose fermenters were found in samples.]

	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920
January	5	16	[1]	18	19	11	19	18	22	14	24
February	10	13	[1]9	14	23	7	24	9	19	10	17
March	16	17	19	14	24	12	27	27	22	20	22
April	7	11	16	22	21	9	25	24	24	21	16
May	12	11	11	23	22	11	26	24	23	20	25
June	17	15	18	22	20	23	20	27	25	23	26
July	14	12	17	19	16	20	18	26	24	25	24
August	18	8	16	6	16	23	15	25	20	26	24
September	14	[1]2	14	11	24	18	15	27	21	22	23
October	21	[1]	16	13	21	23	23	27	11	26	24
November	14	[1]	12	19	19	20	13	28	20	23	20
December	9	[1]	4	25	19	22	13	24	21	23	20
Total	157	104	152	206	244	199	238	286	252	252	265
Monthly average	13	12	14	17	20	16	19	24	21	21	22

[1] Chlorine started September, 1911, and no raw samples were taken until Feb. 8, 1912.

As a rule no samples were taken on Sundays or on holidays, so that in each month the maximum number possible is about 26. It will be observed that this limit is not infrequently reached.

History of improvements.—A brief résumé of the changes in the Cleveland water supply will be of value at this point. Up to 1904 the supply was taken from a crib some 2 miles from shore and was subject to gross pollution, as shown by a very high typhoid rate, reaching 108 per 100,000 in 1903. A new intake 4½ miles from shore was in process of building, and its use was begun in April, 1904, resulting in an immediate drop in the typhoid rate to about 20 per 100,000. As the growth of the city continued and the development of the intercepting sewer system threw more and more fresh sewage into the lake, small winter epidemics, which were due to water and were closely associated with weather conditions, showed clearly that the pollutions of the lake were reaching the intake. The continuous laboratory tests confirmed this, and in 1910 the writer urged upon the city the necessity of additional precautions and suggested the installation of hypochlorite treatment. The idea was accepted, and through three months during the winter of 1910–11 a series of experiments was made with the assistance of Dr. H. D. Haskins, then assistant professor of chemistry in Western Reserve Medical School, and a group of student assistants. With the cooperation of the water department a continuous-flow reservoir containing 75 cubic feet was installed in the medical school building. This apparatus was so arranged that the inflow and outflow were accurately metered, and measured doses of hypochlorite and of *B. coli* could be introduced at will. Thorough mixing was obtained by a series of baffles, and samples were taken from different points and at different depths by a series of continually dropping glass siphons. The experiments showed that with the water as obtained from Lake Erie, a dosage of 0.7 parts per million was necessary to remove *B. coli* from 10c.c. samples and that smaller doses were unsafe. With this dosage, and with the water at that time, there was neither taste nor smell at the end of one hour.

On the basis of these experiments, dosage tanks were set up at Kirtland Street and the treatment was begun in September, 1911. Inasmuch as there was no intermediate reservoir between the intake and the pumps, it was thought best to introduce the hypochlorite at the bottom of the entering shaft, so that it would have for mixing time the height of the column, about 100 feet, and an additional 20 feet or so including an open screen well. This would also admit of aeration and removal of odors. As soon as the apparatus was in working order, the condition of the water improved and the typhoid curve fell with unusual sharpness. Inasmuch, however, as a certain

proportion of the consumers in the immediate neighborhood of the pumping station received the water within less than one hour after treatment, and, consequently, noticed a smell of chlorine from time to time, complaints from this district were frequently received, and the familiar range of diseases and difficulties supposed to be caused by chlorine was gone over again and again. These complaints were decreasing in number when, on February 22, 1912, there was a heavy rain and an associated thaw, which carried an unusual volume of water into the Cuyahoga and brought the trade wastes out as far as the crib and farther. The taste of these wastes had been recorded from time to time in the laboratory records in years prior to the chlorine treatment, but of course in this instance everyone believed it to be due to the chlorine. A storm of protest swept the city hall, and the mayor bent beneath it, ordering a reduction of the dosage. This was done, and inasmuch as the division of health can act toward the water department only in an advisory capacity, the balance between a safe water and an always palatable water was weighed down by the protests, and the dosage has never since been up to the required strength.

In 1914, after another series of floods had proved correct the contention that Cuyahoga River water reached the intake, the writer was appointed on a filtration commission to suggest future plans for the water supply. As a result of the recommendations of the commission, a filter plant of the rapid mechanical type was established at the old pumping station at Division Street (see map), which had been unused since the new intake at Kirtland Street had been put in use. A new tunnel was built, bringing the water directly from a new crib at about the same distance from shore as the one feeding Kirtland Street, and about half a mile farther west. It was supposed that this would supply the entire city, but it was found that the distance and friction head were too great and that it was necessary to keep Kirtland Street in operation, even after the filter plant began service in April, 1918. Through 1918 and 1919 the area served by the two plants varied somewhat; though from the beginning, the West and South Sides and the higher levels were served from Division Street, while the East Side on the lower level had mainly the Kirtland water. In 1920 this was stabilized to the areas shown on the map, though it must be clearly understood that the line of demarcation is not a sharp one. The method of chlorine dosage at Kirtland Street had been altered, as it was found inconvenient to use the long pipes, and the chlorine was introduced in the screen well. The disadvantage of this procedure was that the water went under pressure in a closed circuit within a few minutes after dosage, thus allowing no chance for aeration. In consequence, the area in which a smell of chlorine could be noticed at the tap was markedly

increased. With the installation of the filter plant, a dosage of chlorine was also begun on the filtered water by means of a liquid chlorine automatic apparatus; and in June of the same year, 1918, a similar apparatus was installed at Kirtland Street, the use of bleach being given up.

Character of treated water.—The relation of the amount of chlorine used to the number of lactose fermentations is shown in Table V, which carries the records from the year that chlorine dosage began up to 1920, inclusive.

TABLE V.—*Chronological relation of lactose fermentation and hypochlorite dosage.*

[The first column, indicated by T. ("Times"), shows the number of days during the month in which lactose fermentation was found in the treated samples. From 1911 to 1916, inclusive, the samples recorded were those taken at the tap in the city laboratory, representing water about one hour after dosage. In 1917 and the succeeding years the figures are taken from the reports of the water department, and show the condition of the water a somewhat shorter time after treatment. The second column, labeled Pts. ("Parts per million"), shows the average dosage of hypochlorite during that month.]

	1911		1912		1913		1914		1915		1916		1917		1918		1919		1920	
	T.	Pts.	T.	Pts.	T.	Pts.	T.	Pts.	T.	Pts.	T.	Pts.	T.	Pts.	T.	Pts.	T.	Pts.	T.	Pts.
January	...	....	8	0.73	10	0.34	16	0.68	5	0.40	20	0.33	12	0.30	12	0.39	11	0.29	11	0.22
February	...	....	5	.72	6	.37	15	.61	2	.32	27	.04	6	.20	10	.37	4	.24	1	.22
March	...	....	8	.54	6	.39	15	.50	11	.28	30	.07	5	.19	15	.37	14	.24	1	.24
April	...	....	8	.57	17	.58	22	.50	7	.27	27	.09	26	.17	14	.40	12	.26	8	.27
May	...	....	14	.50	15	.59	25	.48	6	.27	29	.07	13	.24	5	.42	14	.36	15	.32
June	...	....	6	.40	16	.58	13	.46	5	.26	25	.06	17	.36	18	.24	[2] 9	.33	20	.35
July	...	....	2	.32	14	.59	8	.44	12	.28	15	.04	1	.33	6	.24	6	.35	11	.34
August	...	....	5	.45	8	.45	10	.47	20	.31	14	.22	3	.33	12	.24	9	.35	5	.34
September	[1] 6	....	2	.41	10	.43	13	.49	7	.44	8	.27	5	.33	11	.24	5	.35	7	.35
October	16	0.94	4	.40	7	.46	15	.49	23	.44	18	.28	3	.33	8	.24	10	.36	7	.36
November	11	.87	6	.41	12	.55	19	.43	22	.43	4	.31	9	.33	4	.24	5	.33	6	.35
December	9	.59	4	.39	18	.64	11	.39	19	.45	10	.41	3	.28	8	.24	31	.32	13	.35
Average	...	.80	...	.49	...	.50	...	.50	...	.35	...	.18	...	.28	...	.30	...	.31	...	.31

[1] Use of bleach begun.
[2] Use of liquid chlorine begun.

1912—Feb. 1-22, inclusive, 0.75.
Feb. 23-29, inclusive, 0.338.

Before entering into interpretations of the relation of the water supply to the typhoid incidence, there are certain points of technique that must be discussed, lest it appear that injustice is being done to the water department, whose records do not wholly agree with those in the present paper.

The point of difference relates to the confirmation of the presumptive tests for *B. coli*, a question on which there is always a difference of opinion between health office and waterworks.

It is generally agreed that in an unknown water, or one on which a limited amount of work has been done, the presumptive test must be confirmed to eliminate the anaerobic fermentations, which, as shown by Cumming (11) and others, are evidence of a sewage contamination, but offer no evidence of the date of this contamination. Such fermentations ordinarily occur late, after 36 to 48 hours, and sometimes even later, though according to the reports of Frost (10) in connection with the studies of the Ohio River, and from personal

information received from him, as well as from my own work, such formations of gas may occur earlier, though this is rather the exception than the rule. According to many observers, and noted in my own series, it is harder to isolate *B. coli*, or the members of the group, in water which has been filtered or disinfected, even when gas formation in lactose broth is active in the first 48 hours. Moved by these reports and by the results obtained here in routine isolations, the writer undertook some investigations at various seasons on the treated water (which were interrupted by the war). It was found that when plates were made from the tubes showing gas formation *at the end of 48 hours*, a large percentage failed to show *B. coli* or the group, and in many instances there was no growth except a few colonies of aerobic spore formers. In such cases it was found, as might be expected, that the reaction of the tube had become markedly acid. When cultures were made *in the first 24 hours* the percentage of isolations increased, but even here there were a number of failures. When, however, at the time the plates were made, a *subculture from the original fermentation tube* was made into another fermentation tube, this usually showed gas, even when the plates from the original were negative, and from it could be isolated an aerobic nonspore-bearing lactose fermenter. By the use of a good deal of care and persistence, more than is practicable when a large routine series is being run, isolations were obtained in over 90 per cent of cases. In a number of instances sufficient to indicate the general trend, though insufficient for publication or conclusion, the tubes from which aerobic fermenters had been isolated were heated to 80° for 10 minutes, and tested for anaerobic fermenters. The results showed, as might be expected, that there was a more or less constant run of anaerobes, covered in many cases by the more active aerobic gas formers.

The technique pursued at present at the water department laboratories is as follows:

Fermentation tubes of 1 per cent lactose broth are inoculated with 1/10, 1, and 10 c. c. of water and kept at 37° for 48 hours. Plates are then made on Endo from the lowest dilution forming gas, and incubated 48 hours. Characteristic colonies are selected and inoculated into lactose broth, which is examined after 48 hours. From the positive tubes the methyl red and Voges-Proskauer tests are made.

My own work on the Cleveland water has shown that delay till the lapse of 48 hours markedly decreases the positives, though waiting till this time is the routine in the last edition of Standard Methods. Additional work on this subject is in progress in the laboratory to check up former results.

Moreover, in my opinion it is not sufficient to say that because no aerobic fermenters developed on the plates, the gas formation was anaerobic. According to a statement recently sent me by Dr. W. H. Frost, the evidence necessary to this effect is "in such case a transfer directly to another fermentation tube should give gas, and this tube in turn should give negative plates with a positive transfer to a third fermentation tube." This detail is rarely carried out in routine work.

In the Charts 1 and 2, therefore, the figures represent lactose fermentations with more than 10 per cent gas occurring in the first 36 hours without regard to completion of the presumptive test. This probably is excessive, but the writer believes that the curve

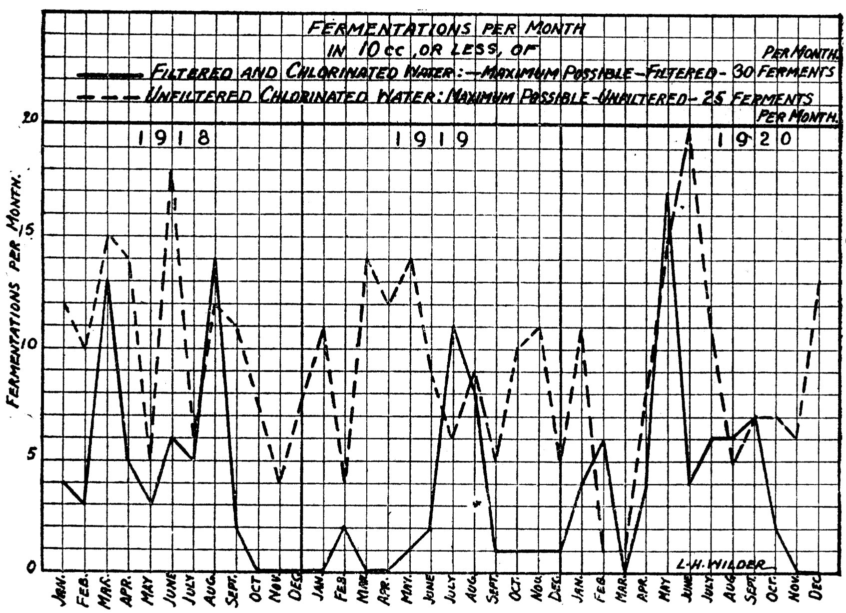

CHART 1.

would be lowered by an average of not more than 10 per cent if the methods above noted could be carried out as a routine.

Graphs comparing the fermentations with the colon findings in the water department records, show a great variation in percentage of confirmations, which does not coincide with weather or season. Taking the filtered and unfiltered supplies separately, the confirmations for 1918, 1919, and 1920 are about 70 per cent in the former and 60 per cent in the latter. Inasmuch as a similar analysis of the raw water tests shows over 95 per cent confirmations, it is clear that the technique is being carefully carried out, and that the difference in the treated waters is due to the difficulties noted above. In sum-

mation, I believe that with painstaking extra-routine work on the early fermentations the percentage of confirmations would approach that of the raw water, and that in any case the *form* of the curve would not be altered materially.

Charts constructed on this basis show the total fermentations with over 10 per cent gas occurring within 36 hours, for the filtered and chlorinated water, and for the unfiltered but chlorinated water. In all discussions in this article the water entering the pipes for delivery to the consumer is the only water considered, the quality at the preliminary stages being omitted from discussion. In Chart 2, similarly constructed, is shown the total fermentations for the water at the city hall tap in the laboratory, revealing its more or less mixed origin in 1918 and 1919, and its close correspondence in 1920 with the curve for the water at Division Street Station, from which it came.

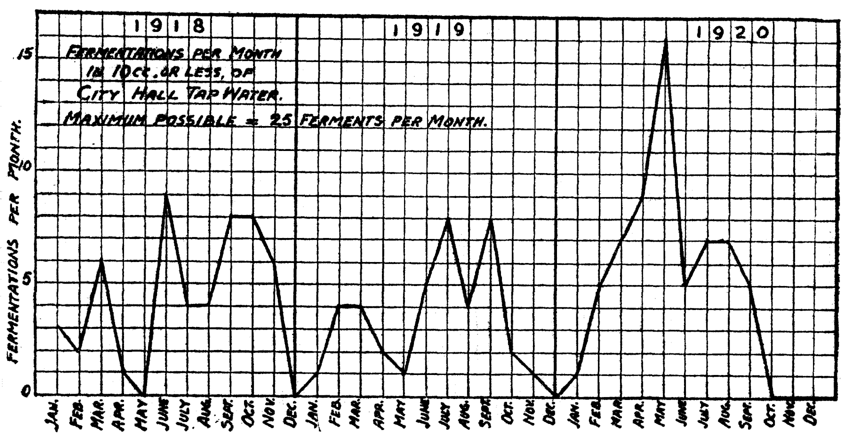

CHART 2.

For completeness, and to avoid criticism of unfairness to the water department, Charts 3 and 4 were prepared. These show the actual unmodified records of that department, with the actual number of days on which fermentation was noted and the actual number of days on which confirmations were made. It will be noted that the solid line on Chart 3 is the same as the dotted line on Chart 1, and that the solid line on Chart 4 is the same as the solid line on Chart 1. It will also be noted, in connection with the subsequent discussion, that the form of both curves is nearly identical in presumptive and in confirmed tests, though the curve for the latter is rather lower throughout.

These figures come from the records of the water department and constitute the basis of their official reports; but, as previously noted, the totals in my charts are based on presumptive rather than confirmed tests.

At the city laboratory of the health division there has been a daily sample taken from the tap since 1903. Prior to 1918 this, of course, represented the unfiltered lake water, and prior to 1911, the unchlorinated unfiltered lake water. In 1918 and 1919 the supply was a variable one, sometimes from Division Street, sometimes from Kirtland Street; but in 1920 it was entirely from Division Street, and the curve (Chart 2) follows closely the curve of the water department for that station.

In the effort to get a check on the Kirtland water, a series of examinations was begun in 1920 from certain of the police stations, taking, on the one hand, from those receiving water from Division Street, and, on the other hand, from those receiving water from Kirtland Street. The agreement of the curves with those of the sources of the water is sufficiently close to be within the limits of error and is a valuable check on the results at the pumping stations.

A summary of the findings in the various supplies is as follows:

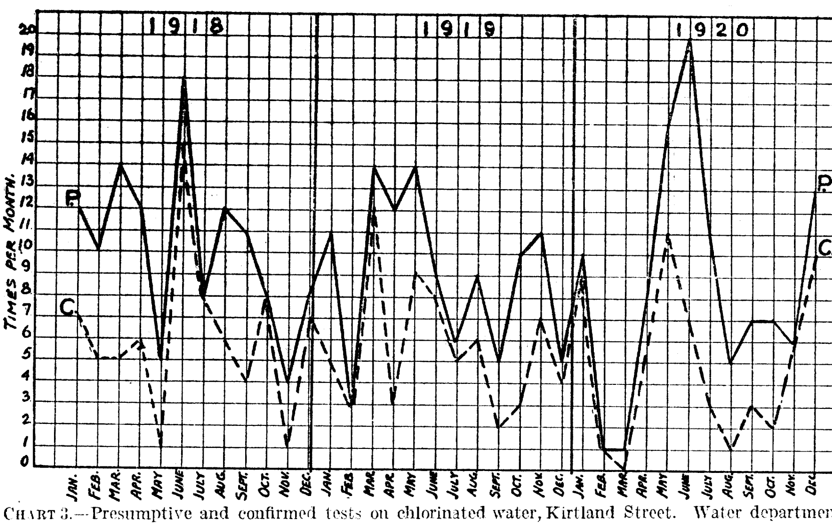

CHART 3.—Presumptive and confirmed tests on chlorinated water, Kirtland Street. Water department findings.

Following first the treated and unfiltered water from the Kirtland Street Station we find the following:

In 1918 the chlorinated water showed fermentation in 40 per cent of the samples (this figure is obtained by dividing the number of days positive by the number of daily examinations) and maintained a more or less constant level, never falling below 20 per cent and only occasionally rising above 50 per cent.

In 1919 there were 37 per cent of fermentation days, with an even more level curve, lying almost entirely between 20 per cent and 50 per cent.

In 1920 there were 35 per cent of fermentation days but with a much wider range, reaching as high as 78 per cent in June and falling to almost nothing in February and March.

Taking the average of these results we find that in the chlorinated water there was fermentation in 37 per cent of all days examined, which, on the basis of an average 90 per cent in the raw water, gives an average reduction of 59 per cent only, showing clearly that the chlorination was inadequate.

Following next the filtered and treated water, we find the following: In 1918 the effluent from the filter plant, after chlorination, showed 22 per cent of fermentation days, the worst periods being in March and in August, when the month percentage passed 50.

In 1920 the same effluent showed 15 per cent, the worst months being May, in which 55 per cent of the days showed fermentation, and June, July, August, and September, which showed an average of 19 per cent.

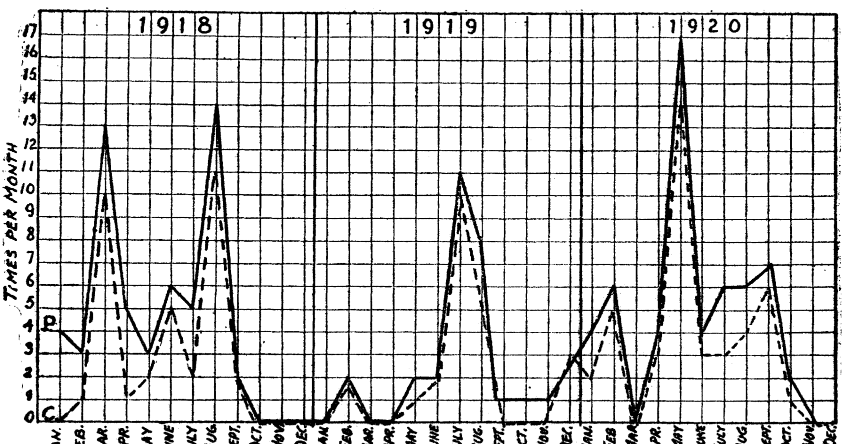

CHART 4.—Presumptive and confirmed tests on filtered and chlorinated water, Division Street. Water department findings.

In 1919 the same effluent showed 8 per cent, more than half of which occurred in the months of July and August, the rest of the year being eminently satisfactory.

Possible Relations of the Water Supply to the Typhoid Incidence.

As a preliminary basis for discussion, Chart 5 was prepared. In this chart the typhoid incidence for the three years has been assembled, with the omission of all cases which were of out-of-town origin, or which showed any definite probable etiology, such as baths along the lake shore or elsewhere in polluted water, within a probable incubation period. In other words, this is, as far as possible with the information at hand, a chart of the residual typhoid.

It will at once be noted that the curves for 1918 and 1920 are practically identical; whereas the curve for 1919, besides being lower, has its rise at a different time. It will also be noted that each of the

three years has a preliminary rise occurring in the spring or early summer. As far as possible the cases have been charted according to the date of onset; but in a good many cases it was necessary to guess at this, and there must be a fair margin of error.

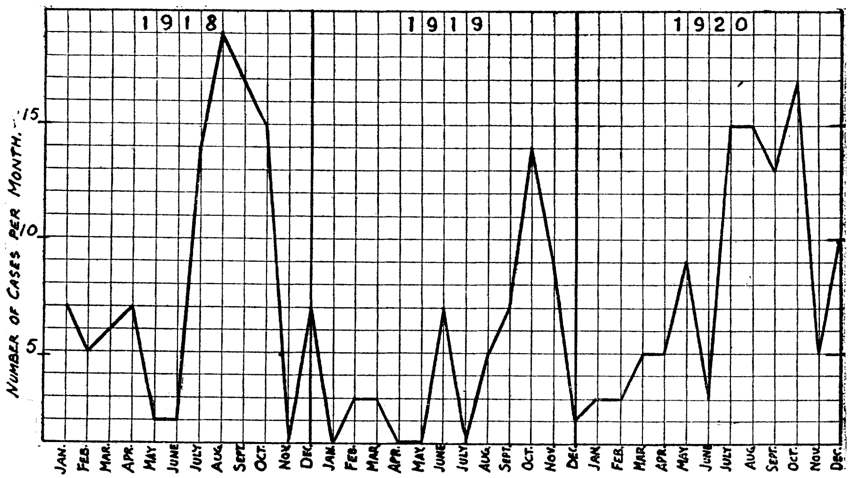

CHART 5.—Corrected monthly incidence of typhoid fever in Cleveland for 1918, 1919, and 1920. (Out-of-town cases and cases of known etiology are omitted.)

In 1918 the bad periods for the filtered and treated water were in March and August, though it was none too good in the interval; and for the unfiltered but treated water, in March, April, and June, with

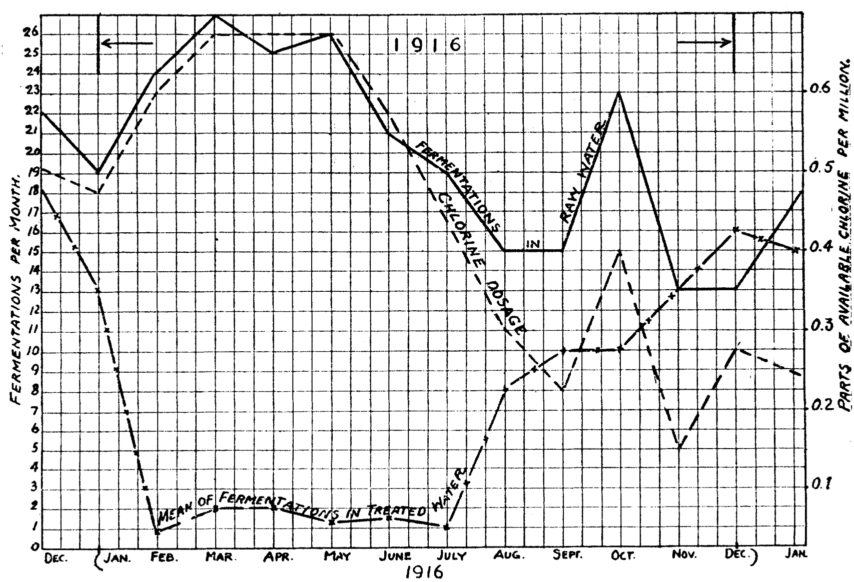

CHART 6.—The effect of low chlorine dosage in 1916.

other earlier and later periods when it was unsatisfactory. In this year the preliminary rise took place in March and April, and there was a notable drop following the best combined period for the first

half of the year. The high level of incidence ran through July, August, September, and October; and it is at least suggestive that

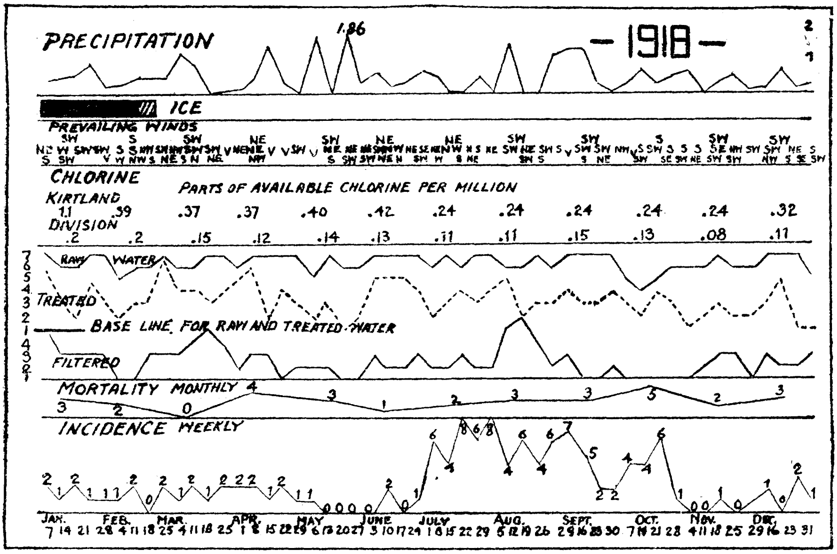

CHART 7.

the worst water combinations occurred in June, July, August, and September.

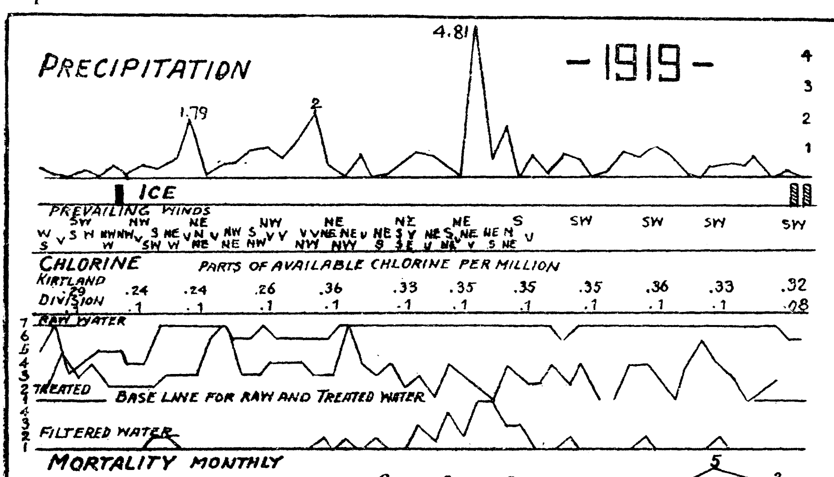

CHART 8.

Passing to 1919, we find that the worst condition of the Kirtland water came in March, April, and May, and that the preliminary rise took place in June; whereas the worst of the filtered water was in July

and August, and the high peak of incidence ran through from the middle of August to the end of October, with a very sharp rise and sharp decline.

In 1920 there was a serious deficiency in the quality of the water from both sources in the months of April, May, June, and July; and after a preliminary rise in May, followed by a fall in June, there was a very sharp rise in July, August, September, and October.

It will of course be urged, and quite properly, that these curves also correspond to the so-called summer typhoid, which may be due to other factors than water. On the other hand, at least in the 1920 cases, every attempt has been made to find out about cases, and it is surprising how many persons are found who had not been out of the city limits in the incubation period, had not been in swimming, had

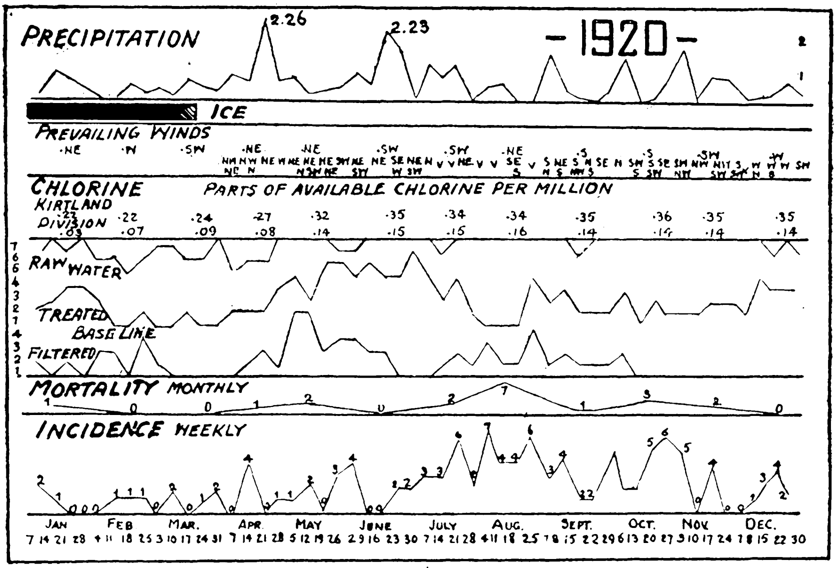

CHART 9.

not eaten at any suspected place, or in fact done anything that is in any way suggestive of an etiological relation. The writer is inclined to believe that although undoubtedly some of the cases have been caused by carriers, or food, etc., yet the removal of these would cause a lowering of the curve rather than a material change in its shape.

The charts have been proportioned to emphasize the heights of the incidence and pollution columns, inasmuch as the total number of cases is not very large, but those for water and typhoid are on the same scale and may be fairly compared. The fact has been long urged and frequently forgotten that a water supply polluted in any degree may give rise to cases varying in number from a series of intermittent and apparently sporadic cases to a definite epidemic, and the scales of the present charts are calculated to emphasize this epidemic type.

In previous publications on this subject there have been numerous instances where the relationship of high frequency of pollution in the water as it reached the consumer was clearly related to rises in the curve of typhoid incidence; and in order to show the relation of the amount of available chlorine to the number of fermentations in the water supply, Chart 6 was prepared, showing how, in 1916, when, for some reason, an unusually small amount of chlorine was used, the curve of pollutions in the treated water followed that for the raw water at a distance inversely proportional to the amount of disinfectant used.

Three complete graphs are also presented, showing rainfall, ice conditions, winds, chlorine administration, and the fermentations in the raw and treated waters, together with the incidence and mortality in the Cleveland cases. This is arranged by weeks, on a vertical scale, as in previous reports, so that the chronological relation can be readily noted. The discussion of the relations of rainfall and ice has been taken up in detail in previous reports, but may be summarized here by the statement that floods in the Cuyahoga River, a solid sheet of ice from shore to cribs, or floating ice passing back and forth near the cribs, have all been found to bear definite relations to the contaminations in the water supply, and often, indeed, to sudden rises in the typhoid incidence. There are no currents in Cleveland Bay save those that are determined by the water from the river, or by the winds, so that winds which tend to carry floating sewage toward the cribs are dangerous, and storms which result in heavy turbidities must also be considered. With this information and with the detailed charts elsewhere in the body of the article these graphs are self-explanatory.

STATEMENTS FROM THE WATER DIVISION.

It is not the desire of the writer to enter upon a controversy with the water department, but it appears proper to quote rather fully from the report submitted in March, 1921, by J. W. Ellms, engineer of water purification for the city, a man of large filter-plant experience. He states, in part, as follows:

"There are two points on which I can not agree with Dr. Perkins in his deductions as to the seeming relationship between typhoid-fever cases and fluctuations in the quality of the supply.

"There is not in the years studied always a rise in typhoid fever corresponding to an increasing or even sustained higher content of *B. coli*, even though at times there does appear to be a certain sequence. In 1918 the rise in typhoid appears to be coincident with a higher *B. coli* content for the disinfected filtered water, although the disinfected raw water remained low.

"During the year 1919 the *B. coli* content of the disinfected raw water was quite high until June, although the content for the filtered water ran very low. Increase in typhoid was not marked until August, reaching a peak in October. However, the *B. coli* content of the water from September until the close of the year was quite low.

"During 1920 the highest *B. coli* content of the water occurred during May and fell off markedly until September. The filtered water continued very low, although there was a slight rise in the *B. coli* numbers in the disinfected raw water.

"The typhoid cases began rising in June, reaching their maximum number in August, but continuing quite high for the remainder of the year. In other words, when the typhoid was the highest and continued so, the water was of better quality than any supplied during the early months of the year.

"The second point I wish to mention is that Dr. Perkins fails to give sufficient weight to the actual numbers of *B. coli* present in the *water supplied to consumers. Certainly no one would deny that a polluted water, such as is now obtained from Lake Erie, is ever free from the presence of this organism, no matter how successful purification processes may appear. It is always present in the distribution system, but that does not necessarily imply that its presence indicates danger.*[1]

"Judged by such standards as bacteriologists tentatively have accepted, the Cleveland supply averages well. For the year 1918 the *B. coli* index was for both disinfected raw water and filtered water about 1.8 per 100 c. c. For 1919 it was 3.6, and for 1920, 3.4. Considering that we are obliged to disinfect raw water for the 40 per cent of the supply, these figures should certainly be given considerable weight.

"A glance at the table showing the quantities of chlorine used will show a treatment that always produces an excess of Cl in the water; and aside from the short period in 1919 when we were having trouble with our chlorine apparatus at Division Avenue, the quantities applied are maintained uniformly and without difficulty. The great excess of chlorine shown during the cold months of the year means, of course, slower reaction velocities, and probably a safer water. However, during the warm months a good excess is usually found. The less excess of chlorine usually found at the Division Avenue plant is due to a longer interval between the time of dosing and the taking of samples.

"In conclusion I may add that I can not believe that there is a sufficient relationship between fluctuations in the quality of the supply and the incidence of typhoid fever cases whose histories do not reveal the source of infection, to attribute the rise in the summer typhoid to the water supply."

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[1] Italics not in original.

DISCUSSION OF STATEMENTS FROM THE WATER DIVISION.

In other words, the water department continues to support the same theses as in the past, namely, that unless *every* period of bad water is followed by an epidemic, *no epidemic* following bad water can be attributed to that factor, even though the sequence may appear; and further, that it is unnecessary to furnish a better water than is being furnished. The same sort of report was made in the discussions when the use of chlorine was under consideration, and again when the question of the need of a filtration plant came up; and these reports are accessible in my files. The sanitary control of the water supply is not vested in the division of health, which is, however, and quite properly, held responsible for the typhoid rate; and for this reason it is important to make the matter clear once for all.

NEED OF A WATER CONFORMING TO FEDERAL STANDARDS.

It is the opinion of the writer and of the Division of Health of Cleveland, that with the available facilities in the form of a modern mechanical filter plant for 60 per cent of the city water, and a liquid chlorine installation for the remaining 40 per cent, a water should be supplied which comes up to the Federal standard for common carriers. These requirements should be met at all times and not for part of the time; and in consequence, the colon index or any other average covering an entire year is misleading, since a bad period may exist and still be of short enough duration to allow of a good average for the year. The graphs showing the findings of the water department, already commented on, show this clearly. The statement italicized, to the effect that no one could expect a water so polluted as Lake Erie to have *B. coli* entirely removed from it, while correct if literally taken, is aside from the point, as the removal to a certain point only is urged.

The Federal bacteriological standard requires that not more than one of five 10 cubic centimeter amounts of the water tested shall show *B. coli* by the methods in current use in the laboratories, and the charts show that there are many periods of some duration in which this is not the case. In the report of the commission appointed by the Secretary of the Treasury to recommend standards of purity for drinking water supplied by common carriers, it was stated further, after detailing the standard, that it is not an ideal one, but merely indicates the *maximum* pollution permissible. It is stated also that this is a standard *which will bring the drinking water supplied by common carriers up to the level of purity of that of satisfactory municipal plants, and that it is not sufficiently stringent to be a burden to them.* The Division of Health believes that the water which is supplied to the people of Cleveland should at all times reach the standard required on rail-

road trains. It would appear that the facts that other cities with pollution as heavy as ours in their raw water succeed in this, and that in our plant we succeed part of the time, without reference to season, indicate that it is possible.

Finally, it is felt that since the water of Lake Erie as supplied to Cleveland for the last 20 years has been found guilty in connection with many outbreaks of typhoid fever; and since every improvement in the supply has been followed by a drop in typhoid incidence, followed again by a slow rise as the population and sewage pollutions increased; therefore, so long as the standard set by the Federal Government is not constantly reached or exceeded, there is cause for grave suspicion of the water supply as an etiological factor in the residual typhoid.

Summary and Conclusions.

1. During the three years, 1918, 1919, and 1920, there were reported or uncovered in Cleveland 346 cases of typhoid in which no etiology other than that related to city conditions could be obtained from the histories, and 90 in which such an etiology was obtained.
2. After further analysis of these city cases and the removal of all in which a definite etiology could be secured, there remained 236.
3. Polluted water at bathing beaches and at other uncontrolled bathing points probably was the etiological factor in a small number of cases.
4. Drinking of grossly polluted water at a drain outlet was the cause of a number of cases in one short period.
5. The number of cases in which contact could be determined as the essential feature was small.
6. Few cases indicated food as the causative factor.
7. During this same period there were two water supplies—one supplying one-fourth to one-third of the population and consisting of lake water treated by chlorination, and the other system supplying the rest of the city and consisting of filtered water, with final treatment by chlorination.
8. Graphs of the tests made on each of these waters showed, as regards the unfiltered chlorinated water, that for nearly half the time there was fermentation in 10 cubic centimeter amounts, indicating that the chlorine dosage was inadequate.
9. Graphs of the tests on the filtered chlorinated waters showed an irregular curve, better in 1919 than in the years before or after, and a fermentation in 10 cubic centimeter amounts of 22 per cent in 1918, of 8 per cent in 1919, and of 15 per cent in 1920. These periods were localized, the curve showing sharp rises and falls ranging from 55 per cent to zero.

10. Graphs of the water as supplied to the city hall and of the water at certain of the police stations agreed almost exactly with the curves of the water at the distribution points.

11. Graphs of the residual cases noted under paragraph 2 showed two rises each year—a small one in the spring or early summer, and a larger one in the late summer or early fall.

12. Comparison of the dates of the onset of these cases showed a rather remarkable relation to the periods when the water was least satisfactory.

13. Inasmuch as it is considered to be practicable to reduce the pollution in either chlorinated or filtered water to a minimum by the means available; and inasmuch as the raw-water supply is constantly grossly polluted; and inasmuch as the number of cases of indeterminate etiology in each of the years in which the water was unsatisfactory was twice that in the year in which the water was best; therefore, it is believed that there is a definite relation between the water supply and typhoid incidence, and that as soon as the pollution in the water as supplied to the consumer is brought to an irreducible minimum, there will be obtained a much better typhoid curve, the residual typhoid being due in such a case to carriers, contacts with missed cases, etc.

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